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A4C CUC C117 C133

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(58) Field of Search
UK CL (Edition P) A4C CUC , B4B
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(54) Abstract Title
Ultrasonic cutting device

(57) A cutting device comprises a generally cylindrical body portion 4 secured indirectly to a source of ultrasonic vibrations by the drive member (6 Fig 1) of a booster, the body portion extending to a cutting blade 10 which is significantly reduced in cross-sectional area, preferably by a factor of at least 4, advantageously by a factor of 8 or more. The cylindrical body portion has a length $\lambda/4$, so that at the point of connection with the drive member (6 Fig 1), an antinode is present, whilst at the junction between the body portion 4 and the cutting blade 10 a node is present. The cutting blade similarly has a length of $\lambda/4$, such that a region of high excitation occurs at the free end. By significantly reducing the cross-sectional area of the cutting blade, an amplification is produced of the longitudinal vibrations as they pass through the body portion 4 into the cutting blade, and thus over the region of the blade adjacent to its free end, significant longitudinal vibrations occur, providing high efficacy of cutting. The cutting edge is also caused to vibrate in a direction transverse to its longitudinal direction (Fig 4c) as a result of the vibrations created by the same source.

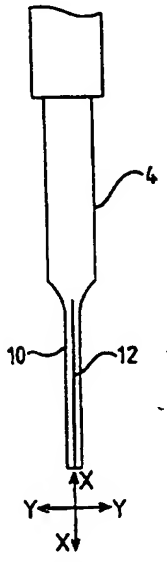

FIG 2

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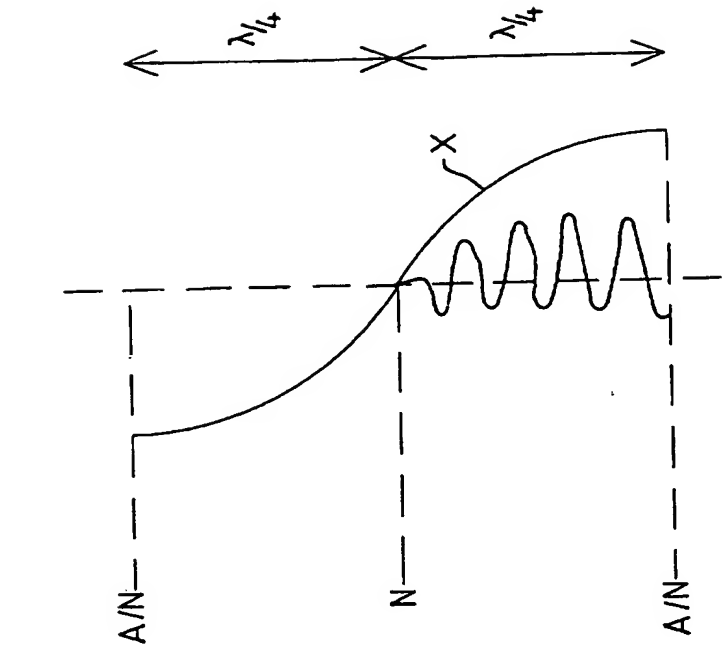


FIG 3

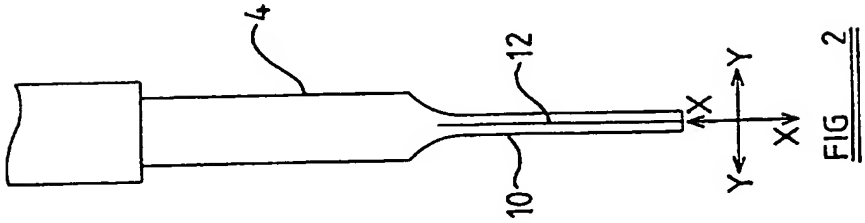


FIG 2

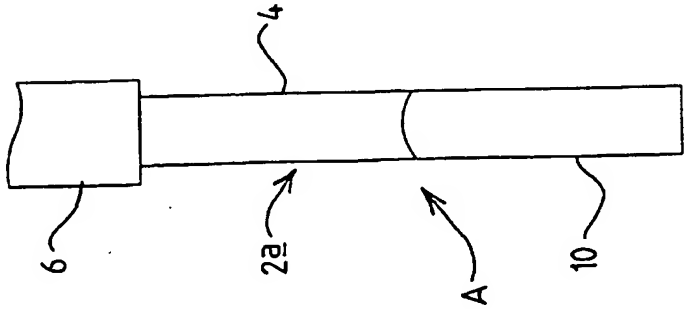


FIG 1

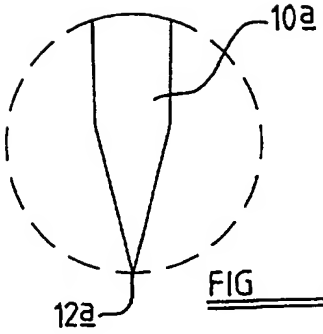


FIG 4a

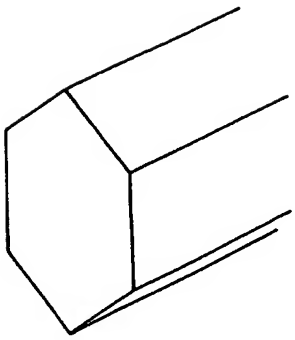


FIG 4e

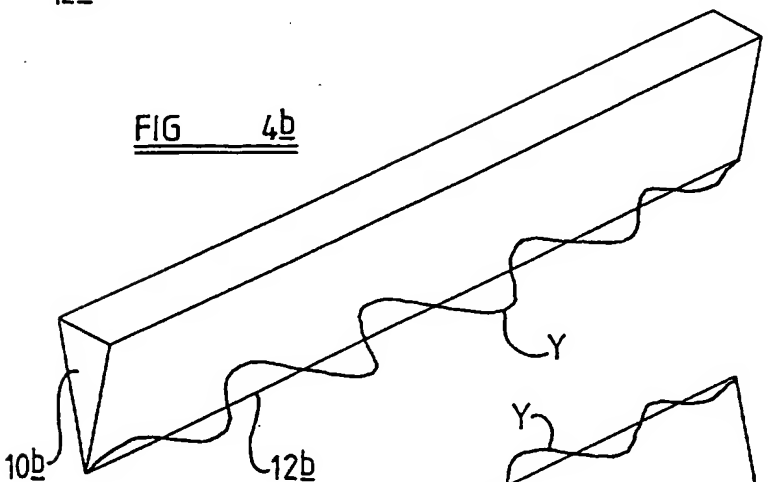


FIG 4b

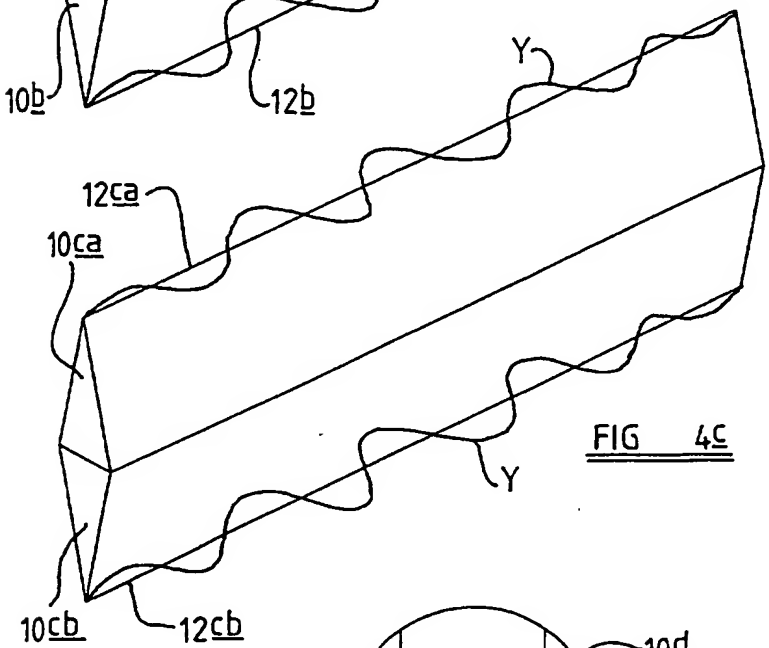


FIG 4c

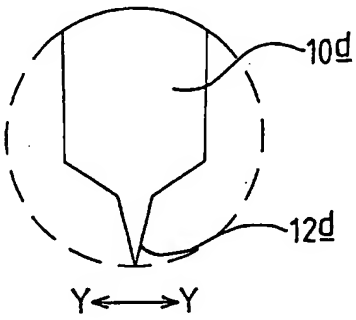


FIG 4d

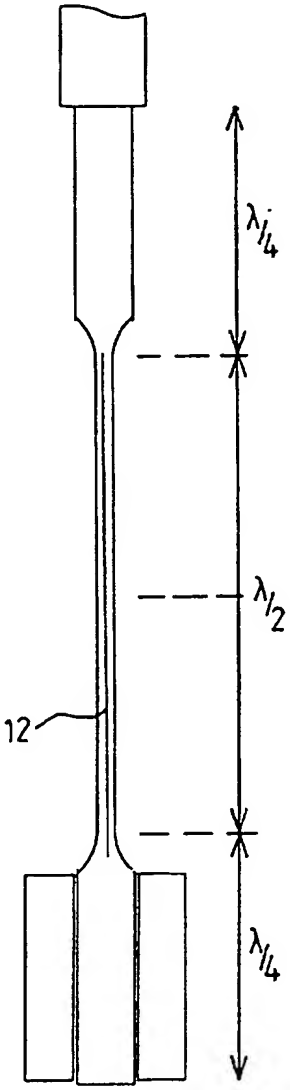


FIG 9

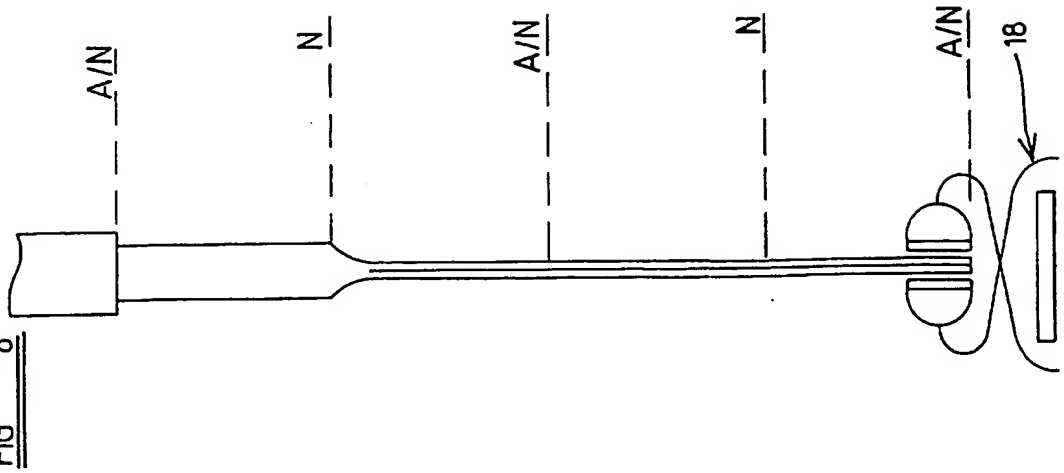


FIG 8

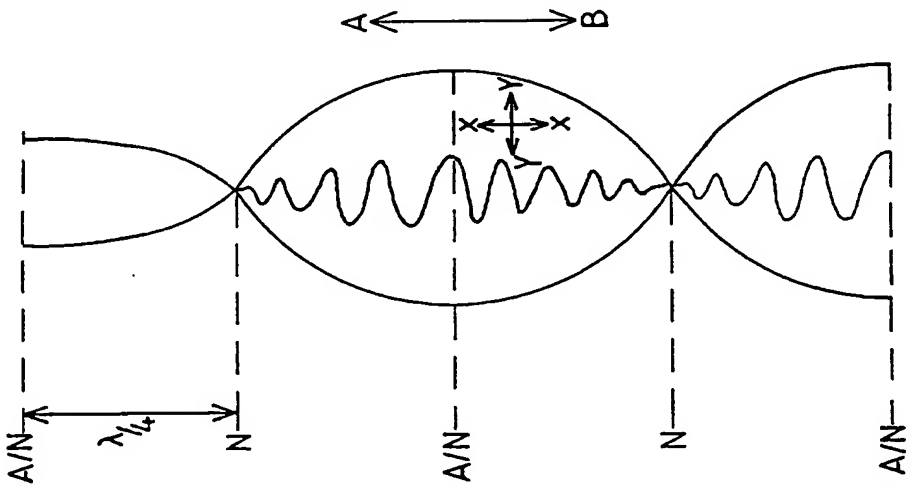


FIG 7

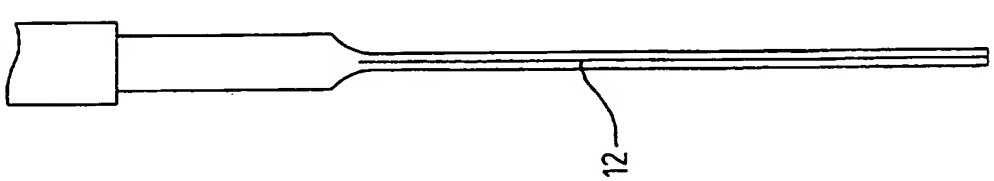


FIG 6

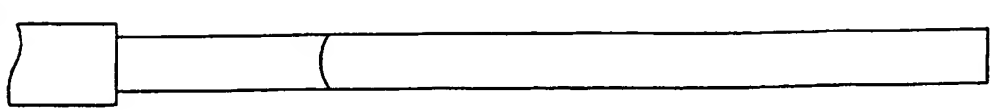


FIG 5

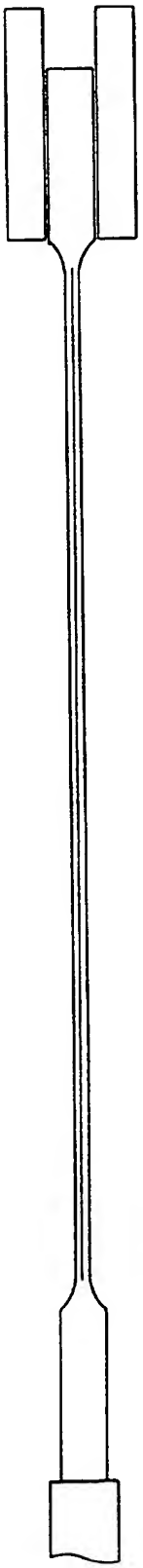


FIG 10

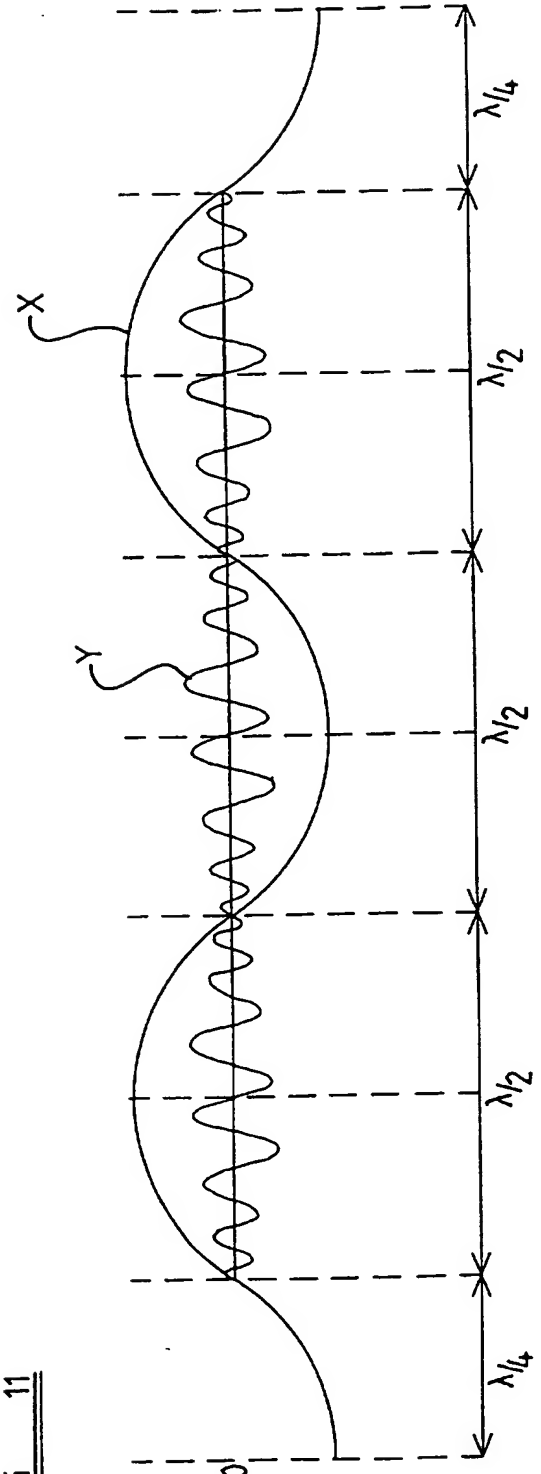


FIG 11

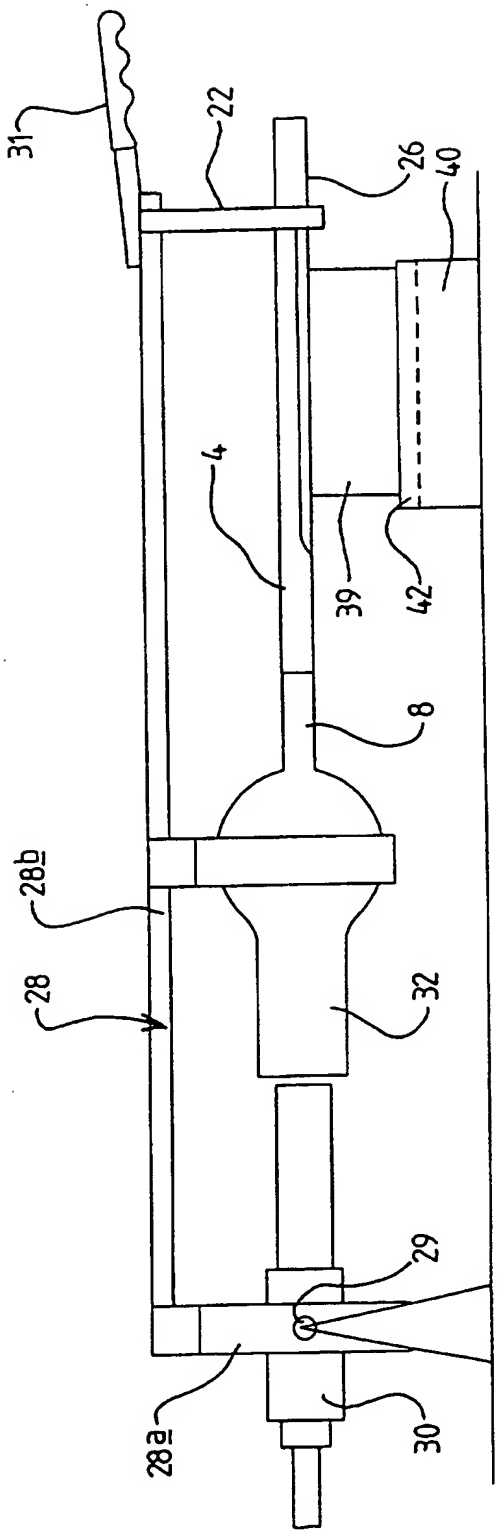


FIG 12

FIG 13

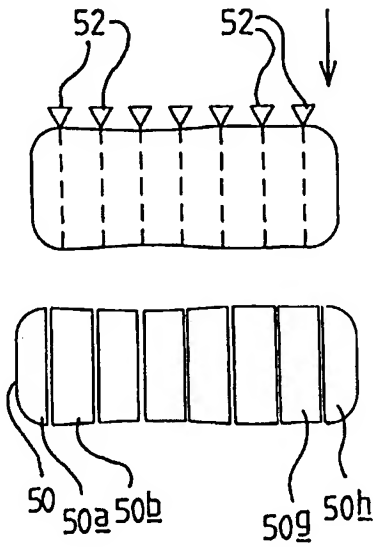


FIG 14

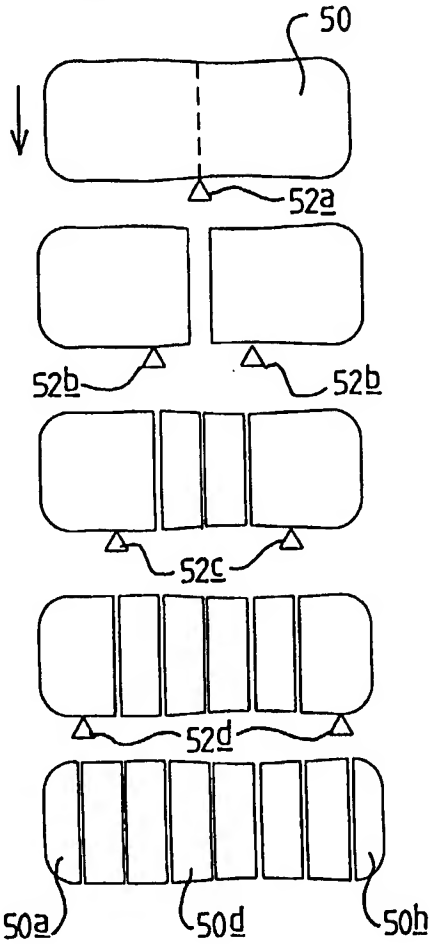


FIG 15

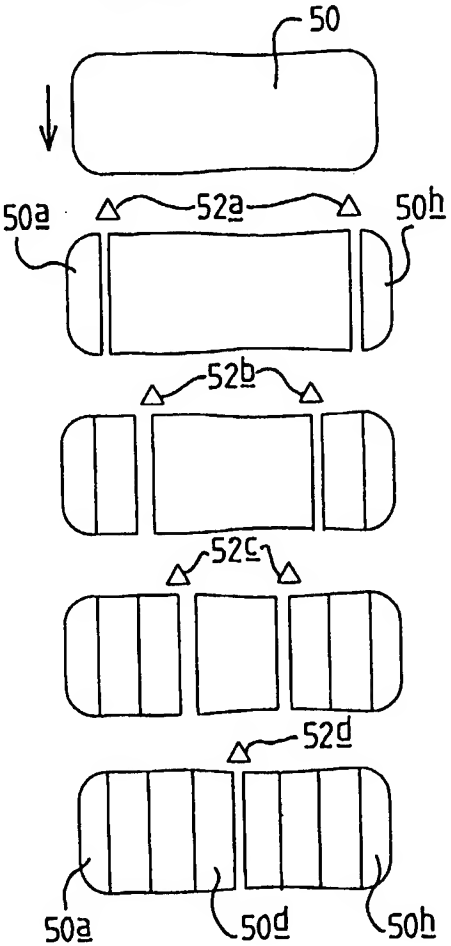
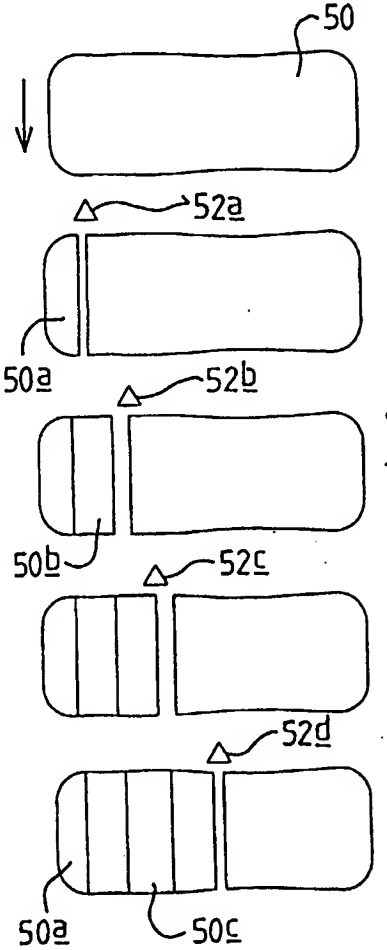


FIG 16



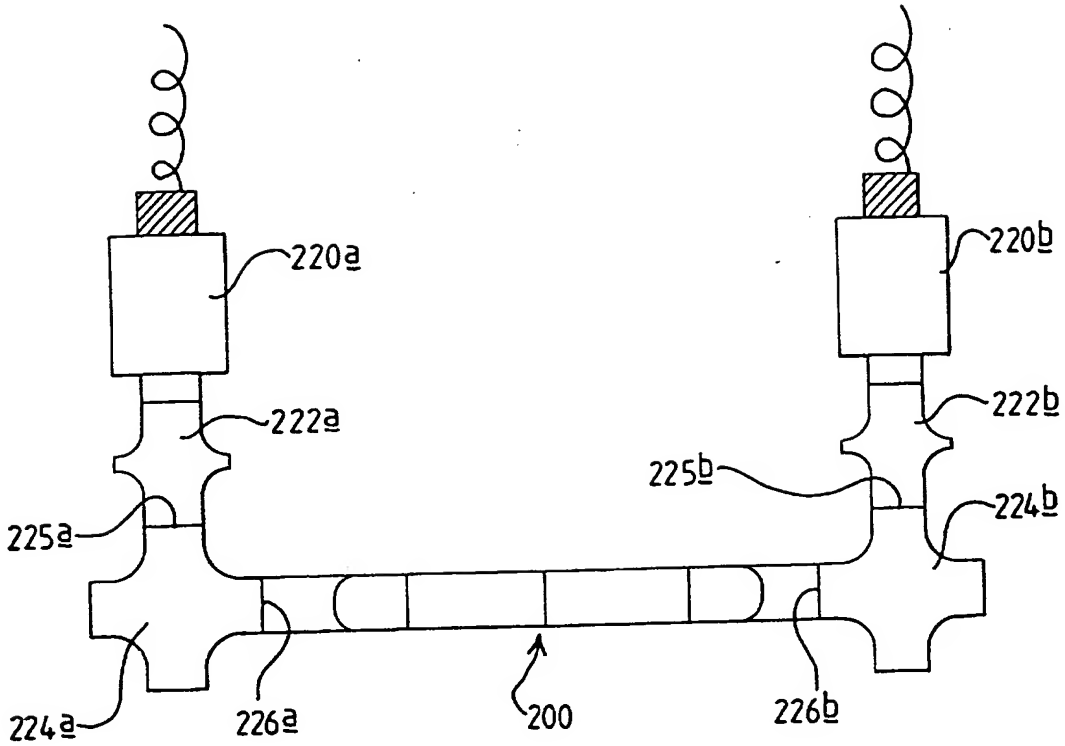

220a
220b
222a
222b
225a
225b
224a
224b
226a
226b
200

FIG 17

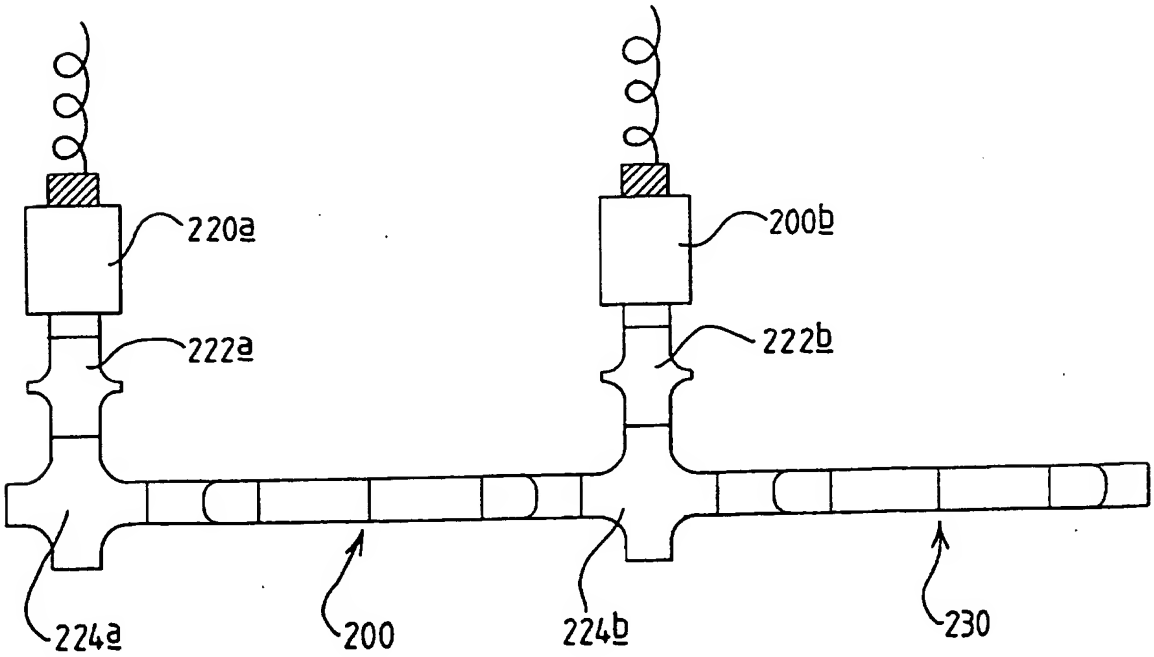

220a
200b
222a
222b
224a
200
224b
230

FIG 18

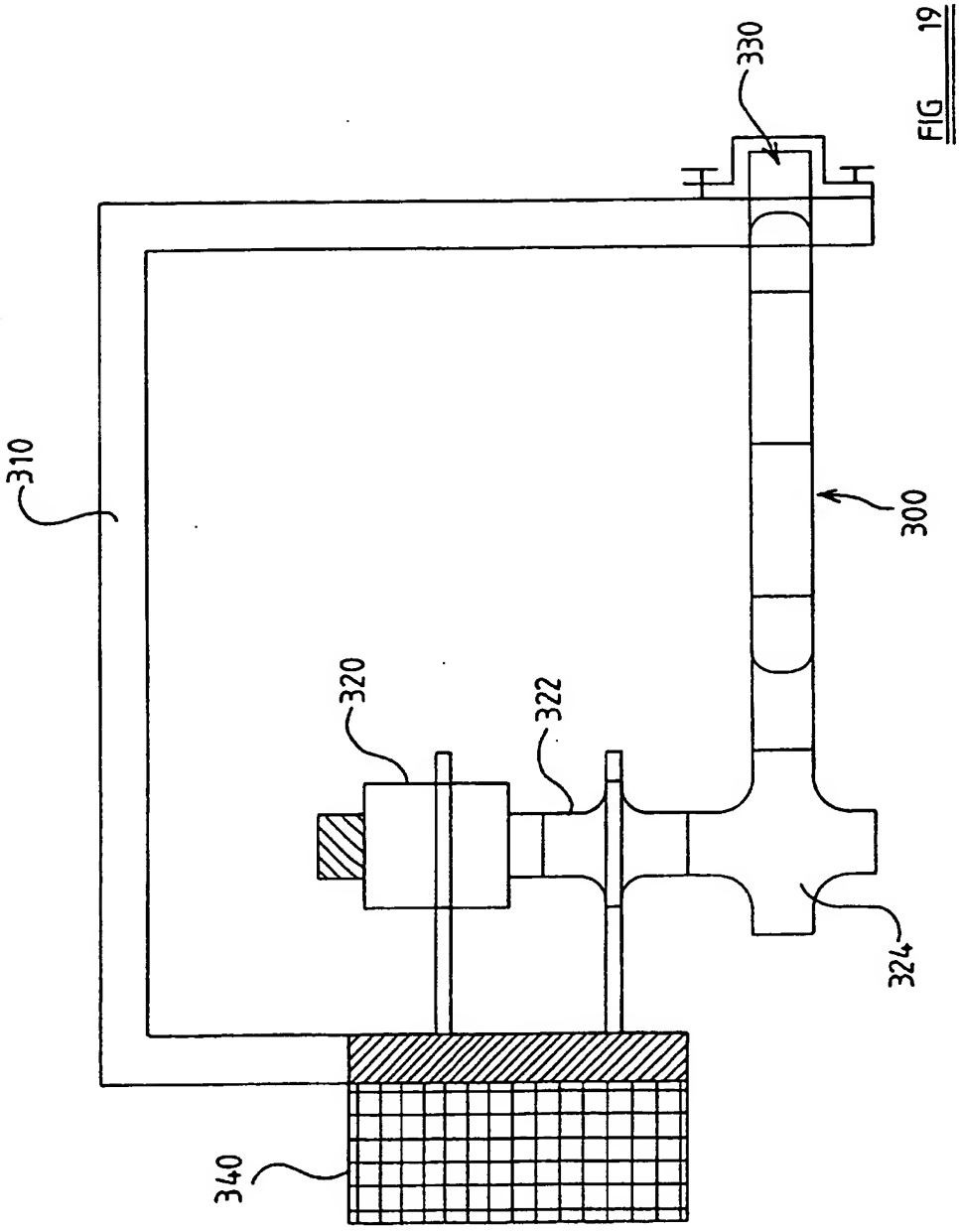


FIG 19

PATENTS ACT 1977

WL/A9159GB/SF-D35

Title: Cutting Devices

Description of Invention

This invention is concerned with improvements relating to cutting devices, particularly but not exclusively for foodstuffs. Cutting foodstuffs, and other materials of a relatively soft and tacky nature, presents difficulties to the food industry. Where it is desired to use a cutting device on passage of the cutting member through the item being cut, the material tends to cling to the cutting blade, and this disrupts the operation of the cutting device, and tends to damage the interior of the item being cut.

According to this invention there is provided a cutting device particularly but not exclusively for foodstuffs, comprising a body portion which in use is connected to a source of high frequency vibrations, the body portion having a longitudinal axis extending parallel to the direction of vibration, and an elongate cutting member extending from the body on the longitudinal direction, the cutting member being provided with an elongate cutting edge extending parallel to said longitudinal axis.

In such a construction I have determined that harmonic vibrations may be produced which lie in a plane containing the longitudinal axis of the device, emanating particularly at the cutting edge, and causing the cutting edge to vibrate in a direction transverse to the longitudinal axis.

The cutting device may be connected to the source of vibration such that the longitudinal axis of the cutting device is co-linear with the longitudinal axis of the source, but may be connected to the source through an intermediate member, such that (for example) the longitudinal axis of the body portion extends at an angle, such as a right-angle, to the longitudinal axis of the source.

The cutting device may be connected to a single source of vibrations, or may be connected between two sources of vibration, conveniently operated in

synchronism, such that the cutting device is driven from opposite ends by a respective source.

In this manner, not only is superior cutting produced by virtue of the longitudinal movement of the cutting edge, but passage of the cutting member through the article to be cut is greatly assisted, particularly where the article is of a soft texture, such as foodstuffs, by the transverse vibrations.

Preferably the frequency at which the source vibrates is between 15 and 150 kHz, typically between 20,30,35 to 40, and 60 kHz.

Preferably the cross sectional area of the cutting member is significantly less than the cross sectional area of the body portion, by which we mean at least by a factor of 2, preferably at least by a factor of 5, and preferably by a factor of 8 or more.

In this manner the amplitude of the longitudinal vibrations transmitted through the body portion is greatly increased as the vibrations pass into the cutting member.

Preferably the width of the cutting member is similar to the width of the body portion, the thickness of the body portion being reduced in a direction at right angles to the longitudinal axis and the depth direction. Preferably the body portion is of circular cross section, and preferably the cutting member is integral with the body portion, and comprises a surface which lies within a cylindrical surface containing the exterior surface of the body portion.

Preferably the body portion is provided with means to enable it to be connected, either directly or indirectly, to a source of ultrasonic vibrations, and is preferably provided with a flat drive surface, extending at right angles to the longitudinal axis, to which surface a drive member, which may be the drive member of a transducer or the drive member of a booster interposed between a transducer and the cutting device, is secured.

Preferably in addition to being tapered by virtue of the provision of a cutting edge, the cutting member is tapered over the majority if not the whole of its thickness, in the direction towards the cutting edge.

Preferably the cutting member has a length of at least $\lambda/4$, preferably $\lambda/2$, and preferably $N\ \lambda/2$, where λ is the wavelength of the vibrations, and N is an integer, preferably being 2.

Preferably the body portion has a length of $\lambda/4$.

Thus a source of vibrations may be attached to the body portion in a high state of excitement, whilst at the transition from the body portion to the cutting member, there exists a region of no vibrations (viz, a node) in the longitudinal direction.

Advantageously the cutting device comprises guide means and/or damping means to restrain the cutting member at a location remote from the body portion against vibrations in an undesired mode. The guide means may be provided by damping plates, between which the cutting member may slide relatively freely in the longitudinal direction. Preferably in such circumstances the cutting member comprises parallel sides at a location remote from the cutting edge, permitting unrestrained vibration of the cutting edge in the said transverse direction but preventing undesired vibration.

Alternatively the damping means may be provided by a damping device secured to the cutting member at an anti-node thereof.

Alternatively the cutting device may comprise a second body portion spaced from the first body portion by the cutting member, and sleeve means in which the second body portion is slidable.

Preferably the cutting device forms part of a cutting machine, and it is another of the various objects of this invention to provide a cutting machine comprising a frame, a transducer or booster nodally mounted on the frame, and at least one cutting device of the kind set out above carried by the frame in vibration-transmitting relationship with the transducer.

Conveniently the frame carries guide means for a portion of the cutting device remote from the transducer. In this way, said remote end portion of the cutting device may be prevented from vibrating in an undesired mode. Alternatively however, the cutting machine may comprise two sources of high

frequency vibrations mounted in spaced relationship, the construction and arrangement being such that opposite ends of the cutting device are connected to a respective one of said sources, whereby, by powering the sources in synchronisation, the cutting device is driven from both ends.

Preferably the cutting device is connected to the transducer through the intermediary of a booster, which transmits vibrations of increased amplitude from the transducer to the body portion of the cutting device.

Preferably the cutting device comprises a second body portion remote from the said body portion, said second body portion passing through sleeve means carried by the frame permitting of substantially only longitudinal movement of the second body portion.

Preferably both body portions have a length of substantially $\lambda/4$, with the cutting member having a length of $\lambda/2$, preferably N $\lambda/2$

In this manner by the application of vibrations to the outer surface of the first said body portion, the centre of the cutting member will be an antinode, and significant vibrations will be found at the cutting edge over a distance of $\lambda/4$, located adjacent to the central antinode of the cutting member, being defined by parts of the blade which have a vibration amplitude of at least 75% of that occurring at the antinode. Additionally, effective cutting may be obtained by the cutting member, by virtue of the transverse vibrations induced at the cutting edge, some distance beyond the fully effective cutting length $\lambda/4$ identified above.

Thus, at a vibrational frequency of 20kHz, the effective cutting length of the blade will be 60-80mm, whilst at 35kHz, the effective cutting length will be 35-40mm.

Another difficulty is encountered in cutting foodstuffs utilising ultrasonics, where it is desired to produce portions of relatively small thickness, such as in the cutting of bread or cakes into conventional slices.

Two main difficulties present themselves, the first being that, in the desired configuration where the cutting members are located side by side so as to carry out simultaneous cutting operations on the item to be cut, significant

compression of the item may be encountered between adjacent cutting members, by virtue of the thickness of the cutting members, which increases the quantity of "crumb" formed, as well as producing unsatisfactory results where the foodstuff is of a soft and/or tacky nature.

The second difficulty which is encountered is in the location of the cutting members in side by side orientation, in that significant constraints are placed on the design of transducer and booster which may conveniently be utilised, and simultaneously providing difficulties should part of the machine (e.g. one cutting member) be required to be replaced.

According to a further aspect of this invention there is thus provided a cutting machine comprising a plurality of cutting devices arranged so as to cut an item particularly but not exclusively of foodstuff into slices, the cutting devices being staggered on the longitudinal direction so as to cut the item into slices in a plurality of cutting operations.

Thus preferably the machine comprises conveying means to convey the items to be cut in relation to the cutting machine, so that the item is engaged by cutting devices one after the other. If desired the serial configuration may be such as to cut the item one slice at a time, or if desired the cutting devices may be arranged in a "chevron" manner, in which two slices are cut from the item by two cutting devices arranged on the same transverse axis, but on opposite sides of the central longitudinal axis, conveniently a single cutting device being utilised initially on the centre line.

Alternatively, a reverse chevron array may be utilised, in which two slices are taken simultaneously from the outer region of the article, terminating in (conveniently) a remaining central portion being cut into two by a single cutting device.

Alternatively the cutting devices are staggered in the longitudinal direction into two groups, alternately spaced so that the first group cuts the item into thick slices, and the second group cut said thick slices into slices of the desired size.

By the use of this aspect of the invention, not only does the staggered arrangement of cutting devices permit greater flexibility in the transducer and booster which is utilised in the performance of the cutting operation, but also the item being cut is subjected to significantly less compression, and less wastage (e.g. "crumb") is produced.

Difficulty is further encountered in cutting devices of the kind described above in producing an effective damping system, which reduces unwanted low energy vibrations, and/or vibrations out of the desired planes.

Thus, preferably cutting devices of the kind set out above are provided with damping mechanisms, which may be

a) piano hammer-type damping pads;

b) "bike brake calliper" type braking pads;

c) viscose damping;

d) a nut and bolt, conveniently of plastics material, secured to the second body portion;

e) an air gel damping mechanism;

f) the use of a water jet;

g) the use of a dash part and/or coil spring damping.

Of course, other types of damping mechanisms may be utilised, as may be deemed appropriate.

There will now be given a detailed description, to be read with reference to the accompanying drawings, of various cutting machines and cutting devices thereof which have been selected for the purposes of illustrating the invention by way of example.

In the accompanying drawings:

FIGURES 1 and 2 are front and side elevations of part of a cutting device which is a first embodiment of this invention;

FIGURE 3 is a view illustrating the vibrational mode of the first embodiment;

FIGURES 4a, 4b, 4c, 4d and 4e illustrate various cross sectional views of cutting blade which may be utilised in the practise of this invention;

FIGURES 5 and 6 are front and side elevations of part of a cutting device which is the second embodiment of this invention;

FIGURE 7 is a view illustrating vibrational mode of the second embodiment;

FIGURE 8 is a side elevation illustrating damping means which may be used in the performance of the invention;

FIGURE 9 is a view illustrating guide means which may be utilised in the practise of the invention;

FIGURE 10 is a side elevation of part of a cutting device which is a third embodiment of this invention;

FIGURE 11 is a view illustrating the vibrational mode of the third embodiment;

FIGURE 12 is a side elevation of a cutting machine incorporating the third embodiment;

FIGURE 13 is a schematic representational view of a conventional method of cutting an article of foodstuff, particularly bread, into slices;

FIGURES 14 and 15 and 16 are views illustrating a third method of cutting an article of foodstuff into slices by the practise of this invention;

FIGURES 17 and 18 are views of alternative arrangements of cutting device in accordance with this invention; and

FIGURE 19 is a schematic view showing a further embodiment of this invention.

The cutting device to A which is the first embodiment of this invention comprises a generally cylindrical body portion 4 secured indirectly to a source of ultrasonic vibrations by the drive member 6 of a booster, the body portion extending to a cutting blade 10 which is significantly reduced in cross sectional area, preferably by a factor of at least 4, advantageously by a factor of 8 or more.

The cylindrical body portion has a length λ/4, so that at the point of connection with the drive member 6, an antinode (region of high excitation) is present, whilst at the junction between the body portion 4 and the cutting blade 10, a node occurs, which is a position of zero or low excitation.

The cutting blade similarly has a length of λ/4, such that a region of high excitation occurs at the free end.

In the preferred embodiment, the cross sectional area of the cutting blade is significantly less than that of the body portion 4, and this produces an amplification of the longitudinal vibrations as they pass through the body portion 4 and into the cutting blade. Thus over the region of the blade adjacent to its free end, significant longitudinal vibrations occur, providing high efficacy of cutting.

There is illustrated in figures 4a, 4b, 4c, 4d, and 4e in which similar numerals with an appropriate suffix are utilised, various cross sectional profiles of cutting blades. In particular I have found that the provision of a larger interior dimension (that is, most remote from the cutting edge 12) compared with the cross sectional dimension approaching the cutting edge provides additional vibrations Y at the cutting edge, and in particular there may be produced vibrations which lie in a plane in which the cutting edge lies, said plane extending parallel to the longitudinal axis, said vibrations thus acting in a direction transverse to the longitudinal vibrations.

It has been found that these transverse vibrations greatly improve the efficacy of the cutting device, particularly on passage thereof through relatively soft tacky materials, such as certain foodstuffs.

If desired the cutting blade may be longer than λ/4, and an increase in the operative length thereof may be effected by increasing the length by λ/8, thus providing an effected cutting length of approximately λ/4.

In the second embodiment of the invention, illustrated in figures 5, 6 and 7, a cutting device is shown which is similar in many respects to the cutting device which is the first embodiment, but in which the cutting blade 10 has a

length of $\lambda/2$, such that the terminal point thereof has substantially zero longitudinal vibration. In such construction, an effective cutting length is provided on opposite sides of the central antinode of the blade, by a distance of approximately $\lambda/8$ in both directions.

Conveniently involving a small further increase in the length of the cutting blade, a damping means 18 may be utilised, comprising damping pads 22 mounted on calliper arms 23, such as to provide a variable restraint to vibration of the blade, which provides greater stability for the cutting portion of the blade during a cutting operation, particularly where the cutting blade is drawn through a block of foodstuff.

A similar arrangement is illustrated in figure 9, where the cutting device comprises a second body portion 26, similarly having a length of $\lambda/4$, with the cutting blade 10 extending there between, over a length of $\lambda/2$. The second body portion 26 may be slidable in sleeve means 22, conveniently afforded by a cylindrical element in which the second body portion 26 is slidably mountable, restraining the cutting blade against a desired vibrational movement whilst permitting unfettered vibrational movement in the longitudinal direction.

The cutting device which is the third embodiment of this invention is also similar to the first embodiment, but comprises a length of $3\lambda/2$, providing a cutting edge of greatly increased length and greatly increased efficacy. In a number of cutting operations, the two nodes which are present along the length of the cutting edge will not cause any difficulty, but if desired any such difficulty may be significantly reduced by moving the cutting device as a whole backwards and forwards in the longitudinal direction, by a distance such as $\lambda/8$.

Figure 12 is a schematic side elevational view of a cutting machine which is a preferred embodiment of this invention, comprising a frame 28, one arm 28a of which carries a transducer 30, the booster 32 being slung beneath a horizontal arm 28b, the drive member 6 of the booster being connected to the body portion 4 of a cutting device of the kind illustrated in figure 10, the second body portion 26 being slidable in sleeve means 22 suspended from the arm 28b.

Conveniently the arm 28a is mounted on a pivot 29, a handle 31 being provided to enable the cutting device to be lifted about the horizontal pivot axis 29. Thus, in use, the cutting device may be utilised to cut an item or work piece 39 mounted on a table or platform 40. The platform 40 may comprise conveyor means to convey the block in a direction at right angles to the plane of the drawing, in a step wise manner, so that the cutting device can be alternately raised and lowered, to cut the block into slices. Conveniently in such an arrangement, the table 40 is provided with a channel 42 into which the cutting blade 10 moves on lowering movement of the handle 23, to permit a completion of cutting of the block.

Where the cutting blade 10 is provided with cutting edges 12 on opposite sides thereof, such as is shown in figure 4c, the cutting device may be operated to move the blade in a cutting action on both the up stroke and the down stroke.

Alternatively the table 40 may be provided with a plurality of radial channels similar to the channel 42, and the table rotated about a vertical axis, enabling the block to be cut into segments.

Figure 12 illustrates schematically a stage in the cutting of an item 50 into slices or portions 50a, 50b.....50g, 50h, by conventional means, using 7 cutting blades 52 disposed side by side, and spaced apart the desired thickness of the slices or portions. In use the cutting blades are passed through the item 50, either by movement of an assembly containing the cutting blades or by movement of the item itself, and the blades in a cutting mode pass through the item 50. During such movement however the cutting blades effect a compression of the item, and where the item is of foodstuff, this may result in the production of excessive crumb, and increases the chance of damage to the interior of the item, particularly where the item is of a soft or tacky nature, such as cake. It had been found that the compressive effect may produce as much as 10% by weight of crumb, significantly increasing the cost of manufacture of the item.

The present invention is particularly useful in ameliorating this problem, particularly when used in the performance of a method which is also illustrative of the invention by way of example.

Thus in figure 13 seven cutting blades are arranged in the form of a chevron, such that the first blade 52a cut the item in half, whilst the following pair of blades 52b cut away two slices or portions spaced from the interior of the central cut which has been provided.

Subsequently a further pair of cutting blades 52c effect cutting of two further slices, whilst two more cutting blades 52d complete cutting of the item 50 into slices.

During each cut following the first, it will be appreciated that compression is occurring primarily only on one side of the line of the cut, and that is a compression in the item over a region which at that stage is not being cut. Not only does this produce a significant reduction in the amount of crumb which is produced, but also damage to the interior of the item due to the blade pulling foodstuff through the item on its leading edge is reduced.

Figure 14 shows a similar arrangement, in which the chevron is reversed, so that two outer slices are removed from the item 15 initially, and successive outermost slices are subsequently removed, terminating in a single cut which divides the innermost portion into two slices. In this way, the amount of crumb which is produced by the initial cut 52a in the arrangement shown in figure 13, is removed.

As a third alternative, the cutting blades may themselves simply be staggered, so that at each pass of a cutting blade, one slice or portion is shaved from the item, prior to passage to the next cutting blade.

As a fourth alternative, the cutting blades may be staggered in two groups, the first group operating on the same transverse line to cut the item simultaneously into a number of slices, at least a majority of which are twice the desired thickness, and a second group operative during a second stage of the cutting operation to cut said thick slices into slices of the desired thickness. Such

separation of the cutting devices into a distance which is twice their normal separation allows considerably greater access to the cutting blades as may be required for maintenance purposes.

It is of course to be appreciated that the cutting devices may be arranged in three groups, operative serially.

The constructions illustrated in figures 13, 14 and 15 lend themselves particularly to use with the present invention, in that the offset and staggering of the cutting blades reduce the constraint of the size of the transducer 32 and booster 30, allowing the superior cutting efficacy which is obtained in accordance with the first aspect of the invention to be used with particular useful effect in the cutting of items of a soft or tacky nature, such as cakes or fruit bread.

In the embodiments hereinbefore described, cutting machines are shown in which the cutting member vibrates on a longitudinal axis which is co-linear with the longitudinal axis of the source (e.g. transducer, or transducer/booster combination). However it is within the scope of this invention for the cutting device to be connected to a source of vibrations in such a manner that the cutting device vibrates on a longitudinal axis which is different from that of the source.

For example, there is shown in Figure 17 a cutting device 200 having a length of N $\lambda/2$, where N is specifically 4. In the embodiment shown in Figure 17, a first transducer 220a is connected to a booster 222a, which in turn is connected to a cruciform member 224a, said member 224a having a responsive face 225a, and an operative face 226a. The construction is such that the face 225a operates as an anti-node, as does the face 226a, thus causing the cutting member 220 to vibrate in the manner as hereinbefore described.

Additionally, the device shown in Figure 17 comprises a second transducer 220b, a second booster 222b, and a second cruciform member 224b, to which the opposite end of the cutting member 200 is connected.

By operating the transducers 220a and 220b synchronously, the cutting member 220 is vibrated from opposite ends thereof, effectively doubling the power input to the cutting member.

It is to be appreciated that whilst the cutting member shown in Figure 16 has a length of 2 λ, other values for the integer N may be utilised.

In Figure 18, in which similar numerals have been used for like parts, a modification is shown in which a secondary cutting member 230 is connected to an opposite drive face of the cruciform member 224b, which may if desired be free at its end remote from the member 224, or which may be damped, to prevent undesired vibrational modes, or may be connected to a further cruciform member 224c (not shown).

Notwithstanding, whilst the invention has been devised particularly for use in the cutting of foodstuffs, it is to be appreciated that the invention may be utilised in the cutting of items other than foodstuff, even where similar or analogies problems to those encountered in the cutting of foodstuffs do not apply. Thus, the cutting machine of the present invention may be used as a hacksaw, in the cutting of bar stock, or in the cutting of bodies of solid material such as wood or plastic into slice-like portions, and there is shown in Figure 19 a practical embodiment of the invention, in which a transducer 320 is mounted on a frame 310, which is connected to a booster 322 generally as hereinbefore described. A cutting member having an operative length of 2 λ is connected to the booster 322 by the use of a cruciform member 324, so that the longitudinal axis of the cutting member 300 extends at right angles to the longitudinal axis of the transducer/booster combination. The end portion of the cutting member 300 remote from the member 324 is slidably received in a guide means generally indicated by the numeral 330.

In use, the cutting member 300, which acts as a hacksaw blade, is presented either manually or automatically to the workpiece to be cut, to effect severing of a portion thereof, which may be accomplished in a very convenient

manner, involving low noise, low power consumption and low generation of wasted heat.

If desired the construction shown in Figure 19 may be modified by the use of a low frequency mechanical vibrating member 340, which may conveniently be mounted on the frame, and which may be connected to the transducer and booster such as to cause relatively low frequency vibrations thereof in a direction extending at right angles to their longitudinal axes, viz in a direction parallel to the longitudinal axis of the cutting member 300, such that in addition to the cutting member vibrating at ultrasonic frequency, it is also moved back-and-forth, with the cutting member sliding within the guide means 330, to improve the efficacy of cutting.

Alternatively, the cutting machine of the present invention may be utilised in the form of a guillotine.

CLAIMS

1 A cutting device comprising a body portion adapted to be connected to a source of high frequency vibrations to cause the body portion to vibrate at high frequency with the direction of vibration extending parallel to a longitudinal axis thereof, and an elongate cutting member extending from the body portion in the longitudinal direction, the cutting member being provided with an elongate cutting edge extending parallel to said longitudinal axis.

2 A cutting device according to claim 1 wherein the construction and arrangement is such that harmonic vibrations are produced which lie in a plane containing the longitudinal axis of the cutting member, emanating at the cutting edge, and causing the cutting edge to vibrate in a direction transverse to the longitudinal axis.

3 A cutting device according to one of claims 1 and 2 wherein the body portion is adapted to be connected to a source of vibrations such that the longitudinal axis of the body portion is co-linear with the longitudinal axis of the source.

4 A cutting device according to one of claims 1 and 2 wherein the body portion is adapted to be connected to a source of vibrations through an intermediate member such that the longitudinal axis of the body portion extends at an angle to the longitudinal axis of the source.

5 A cutting device according to any one of the preceding claims wherein the body portion is adapted to be connected to a single source of vibrations.

6 A cutting device according to any one claims 1 to 4 which is adapted to be connected between two sources of vibration.

7 A cutting device according to claim 6 wherein the two sources of vibration are operated in synchronism, and the cutting device is driven from opposite ends by a respective source.

8 A cutting device according to any one of the preceding claims wherein the source vibrates at a frequency between 15 and 150 kHz.

9 A cutting device according to any one of the preceding claims wherein the cross-sectional area of the cutting member is significantly less than the cross-sectional area of the body portion.

10 A cutting device according to any one of the preceding claims wherein the cross-sectional area of the cutting member is less by a factor of at least 2 than the cross-sectional area of the body portion.

11 A cutting device according to any one of the preceding claims wherein the cross-sectional area of the cutting member is less by a factor of at least 5 than the cross-sectional area of the body portion.

12 A cutting device according to any one of the preceding claims wherein the cross-sectional area of the cutting member is less by a factor of 8 or more than the cross-sectional area of the body portion.

13 A cutting device according to any one of the preceding claims wherein the width of the cutting member is similar to the width of the body portion, the thickness of the body portion being reduced in a direction extending at right angles to the longitudinal axis and the depth direction.

14 A cutting device according to any one of the preceding claims wherein

the body portion is of circular cross-section.

15 A cutting device according to claim 14 wherein the cutting member is integral with the body portion, and comprises a surface which lies within a cylindrical surface containing the exterior surface of the body portion.

16 A cutting device according to any one of the preceding claims wherein the body portion is provided with means to enable it to be connected to a source of ultrasonic vibrations.

17 A cutting device according to claim 16 wherein the body portion is provided with a flat drive surface extending at right angles to the longitudinal axis, to which surface a drive member may be secured.

18 A cutting device according to any one of the preceding claims wherein the cutting member is tapered over at least the majority of its thickness, in the direction towards the cutting edge.

19 A cutting device according to any one of the preceding claims wherein the cutting member has a length of $\lambda/4$, preferably $\lambda/2$, where λ is the wavelength of the vibrations.

20 A cutting device according to claim 19 wherein the cutting member has a length of N $\lambda/2$.

21 A cutting device according to any one of the preceding claims wherein the body portion has a length of $\lambda/4$, where λ is the wavelength of the vibrations.

22 A cutting device according to any one of the preceding claims comprising guide means and/or damping means to restrain the cutting member at a

location remote from the body portion against vibrations in an undesired mode.

23 A cutting device according to claim 22 wherein the guide means comprises damping plates between which the cutting member may slide relatively freely in the longitudinal direction.

24 A cutting device according to claim 23 wherein the cutting member comprises parallel sides at a location remote from the cutting edge, permitting unrestrained vibration of the cutting edge in said transverse direction but preventing undesired vibration.

25 A cutting device according to claim 22 wherein the damping means is provided by a damping device secured to the cutting member at an antinode thereof.

26 A cutting device according to any one of the preceding claims comprising a second body portion spaced from the first body portion by the cutting member, and sleeve means within which the second body portion is slidable.

27 A cutting machine comprising a frame, a transducer or booster nodally mounted on the frame, and at least one cutting device according to any one of the preceding claims carried by the frame in vibration-transmitting relationship with the transducer.

28 A cutting machine according to claim 27 wherein the frame carries guide means for a portion of the cutting device remote from the transducer.

29 A cutting machine according to claim 27 comprising two sources of high frequency vibrations mounted in spaced relationship, opposite ends of the cutting device being connected to a respective one of said sources whereby, by

powering the sources in synchronisation, the cutting device is driven from both ends.

30 A cutting machine according to any one of claims 27 to 29 wherein the cutting device is connected to the transducer through the intermediary of a booster which transmits vibrations of increased amplitude from the transducer to the body portion of the cutting device.

31 A cutting machine according to any one of claims 27 to 30 wherein the cutting device comprises a second body portion remote from the said body portion, said second body portion passing through sleeve means carried by the frame, permitting of substantially only longitudinal movement of the second body portion.

32 A cutting machine according to any of claims 27 to 31 wherein both body portions have a length of substantially $\lambda/4$, with a cutting member having a length of $\lambda/2$, preferable N $\lambda/2$.

33 A cutting machine comprising a plurality of cutting devices arranged so as to cut an item into slices, the cutting devices being staggered in the longitudinal direction so as to the cut the item into slices in a plurality of cutting operations.

34 A cutting machine according to claim 33 comprising conveying means to convey the items to be cut in relation to the cutting machine, so that the item is engaged by cutting devices one after the other.

35 A cutting machine according to claim 34 wherein the serial configuration is arranged to cut the item one slice at a time.

36 A cutting machine according to claim 35 wherein the cutting devices are arranged in a chevron manner, in which two slices are cut from the item by two

cutting devices arranged on the same transverse axis but on opposite sides of the central longitudinal axis.

37 A cutting machine according to claim 36 comprising an additional cutting device arranged on the centre line.

38 A cutting device according to claim 37 wherein the cutting devices are arranged in a reverse chevron array in which two slices are taken simultaneously from the outer region of the article.

39 A cutting machine according to claim 33 wherein the cutting devices are staggered in the longitudinal direction into two groups which are alternately spaced so that the first group cuts the items into thick slices, and the second group cuts the thick slices into slices of the desired size.

40 A cutting machine according to any one of claims 33 to 39 wherein the cutting devices are in accordance with any one of claims 1 to 32.

41 The invention according to any one of the preceding claims comprising damping mechanism selected from the group consisting of :

a) piano hammer-type damping pads;
b) "bike brake calliper" type braking pads;
c) viscose damping;
d) a nut and bolt, conveniently of plastics material, secured to the second body portion;
e) an air gel damping mechanism;
f) the use of a water jet;
g) the use of a dash part and/or coil spring damping.

42 A cutting device arranged substantially as hereinbefore described, with

reference to the accompanying drawings.

43 A cutting machine constructed and arranged substantially as hereinbefore described, with reference to the accompanying drawings.

44 Any novel feature or novel combination of features hereinbefore described and/or shown in the accompanying drawings.

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): A4C(CUC) ; B4B

Int Cl (Ed.6): A23G(1/20) ; B26D(7/00, 08) ; B26F(3/00)

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,E	GB 2313083 A	(RAWSON), see whole document.	1,3-5,8-22,27
A	GB 2299046 A	(SOCIETE)	
Y	GB 2282559 A	(RAWSON), see fig 3.	6,7
A	GB 2270025 A	(SOCIETE)	
X	EP 0543628 A1	(UNILEVER), see whole document.	1,3-5,8-13,16-21
Y			6,7
A	WO 96/09919 A1	(UNILEVER)	
X	WO 93/14912 A1	(RAWSON), see whole document.	1,3-5,8-27
Y			6,7
X	US 3817141	(SIMONETTI), see whole document.	1,3,8-13,16-18
Y			6,7

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